PROGRESS in the IMPLEMENTATION of MOTOR VEHICLE EMISSION STANDARDS THROUGH JUNE 1975

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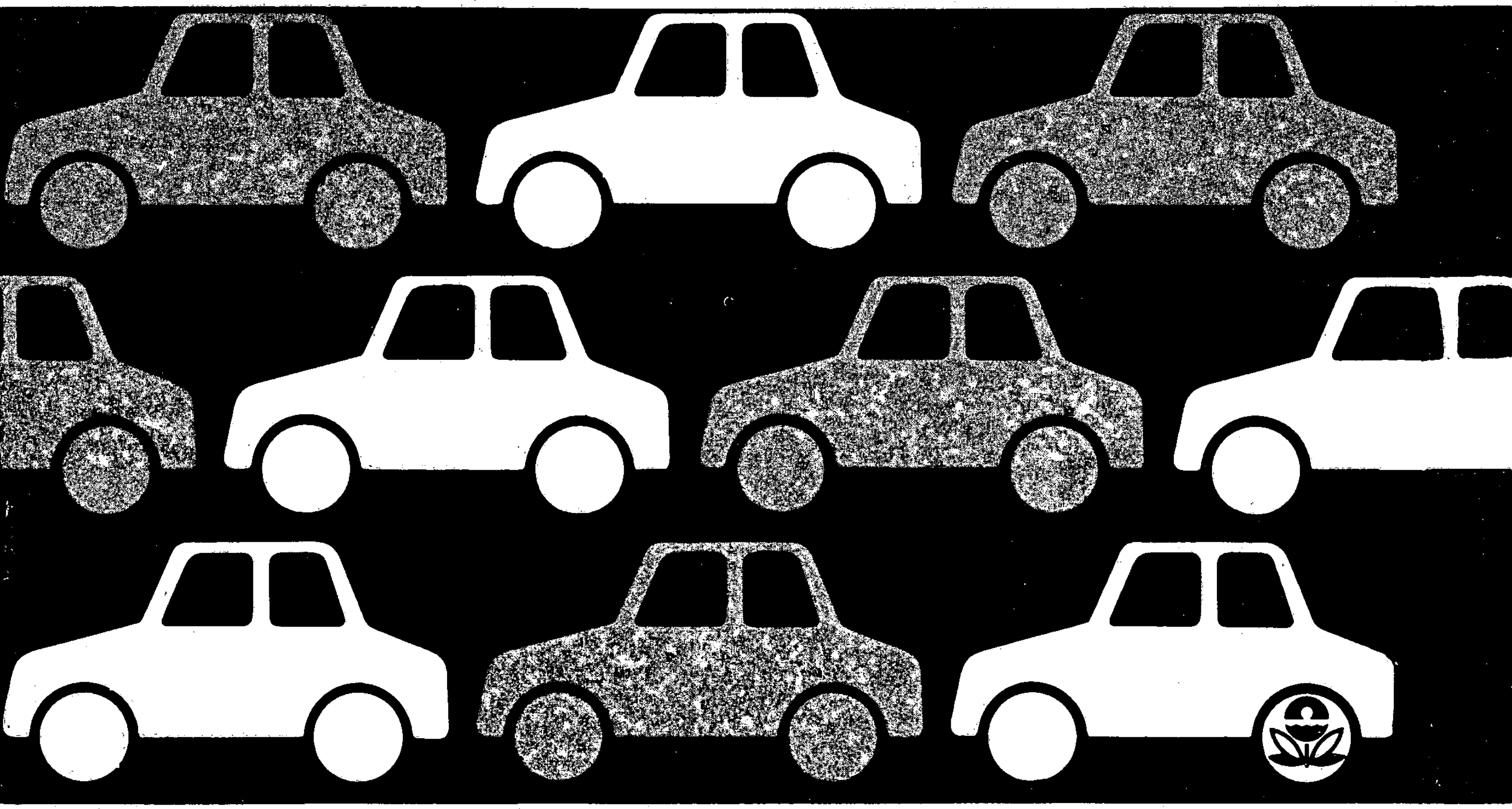

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Report to Congress

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PREFACE

The Clean Air Act, as amended in 1970, initiated a coordinated national effort toward reducing air pollution through research, regulations, enforcement, and related programs.

Section 202(b)(4) of the Clean Air Act requires the EPA Administrator to report yearly on measures taken in relation to motor vehicle emission control. Section 202(b)(4) reads as follows:

> "On July 1, 1971, and of each year thereafter, the Administrator shall report to the Congress with respect to the development of systems necessary to implement the emission standards established pursuant to this section. Such reports shall include information regarding the continuing effects of such air pollutants subject to standards under this section on the public health and welfare, the extent and progress of efforts being made to develop the necessary systems, the costs associated with development and application of such systems, and following such hearings as he may deem advisable, any recommendations for additional Congressional action necessary to achieve the purposes of this Act. In gathering information for the purposes of this paragraph and in connection with any hearing, the provisions of Section 307(a) (relating to subpoenas) shall apply."

This report covers the period July 1, 1974 through June 30, 1975. It has not been updated to reflect changes that have occurred since June 30, 1975.

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CHAPTER I. INTRODUCTION AND SUMMARY

The period for this report (July 1, 1974 - June 30, 1975) saw continued development and refinement of EPA activities to control emissions from new motor vehicles.

The Energy Supply and Environmental Coordination Act of 1974 enacted new deadlines for the emissions standards originally established under the Clean Air Act Amendments of 1970. The Energy Act changed the deadlines for meeting the hydrocarbon (HC) and carbon monoxide (CO) emission standards from 1975 (specified in the Clean Air Act) to 1977, with the possibility of a 1-year suspension. On March 5, 1975, the EPA Administrator suspended the 1977 HC and CO emissions standards and, as required by law, established interim standards for the 1977 model year. The standard for emissions of oxides of nitrogen (NOx) remained at the interim level previously set by the Administrator. Standards are summarized in Tables I-1 and I-2.

Legislative proposals to revise standards are now under consideration. In March 1975, the EPA Administrator recommended that the present interim standards of 1.5 grams/mile HC, 15 grams/mile CO, and 2.0 grams mile NOx be extended through 1979 and that a sulfuric acid emission standard be adopted for 1979 model year vehicles. For 1980 and 1981 model years, the Administrator suggested levels of 0.9 grams/mile HC, 9.0 grams mile CO, and 2.0 grams mile NOx. In July, 1975, the President proposed that the present standards be extended through the1981 model year. The Congress is presently considering these and other proposals for the revision of the statutory requirements for emission reduction.

The past year saw a number of other developments as EPA:

- Continued to support research on effects of motor vehicle emissions and continued to assess the technology of emission controls.

- Through the recall program, tested vehicles in use and supervised manufacturer initiated recalls of 428,558 vehicles that had defective or deteriorated emission control systems.

- Implemented Regulations requiring the availability of unleaded gasoline needed to protect catalytic converters and making it illegal to sell unleaded gasoline which is found to be contaminated with lead.

- Published figures on fuel economy of 1975 model year vehicles and urged manufacturers to participate in the voluntary program for labelling new automobiles with fuel consumption data.

- Promulgated regulations requiring that manufacturers demonstrate compliance with emission standards for vehicles initially to be sold at altitudes of 4000 feet or above.

- Developed a program for ensuring that vehicles driven abroad on leaded gasoline are properly fitted with operational catalytic converters upon reentry into the United States.

- Initiated development of a program of voluntary self-certification for manufacturers of aftermarket parts which are important to performance of emission controls.

- Proposed the Selective Enforcement Audit method of ensuring compliance with exhaust emission standards at the point of automobile production.

- Held hearings and prepared technical reports on the status of sulfuric-acid emissions.

- Investigated tampering with emissions control systems.

- Continued the new car certification testing program.

- Continued program of periodic audits of vehicle manufacturers to ensure that certification procedures are being observed.

- Continued development of the short test necessary for implementation of the performance warranty in Section 207(b) of the Clean Air Act.

The major regulatory actions undertaken by EPA are summarized in Table I-3.

TABLE I-1

EMISSION STANDARDS FOR LIGHT-DUTY MOTOR VEHICLES (GRAMS/MILE)

MODEL YEAR		1975 HC	1975 CO	1975 NOx	1976 HC	1976 CO	1976 NOx	1977 HC	1977 CO	1977 NOx	1978 HC	1978 CO	1978 Nox
LIGHT DUTY	PASSENGER												
	NATIONAL	1.5	15	3.1	1.5	15	3.1	1.5	15	2.0	0.41	3.4	0.4
	CALIFORNIA	0.9	9.0	2.0	0.9	9.0	2.0	0.41	9.0	1.5 [1]	2	2	2
LIGHT DUTY	TRUCK												
	NATIONAL	2.0	20	3.1	2.0	20	3.1	2.0	20	3.1			
	CALIFORNIA	2.0	20	2.0	0.9	17	2.0 [1]						

1. Waiver granted
2. California will be in compliance with the Federal standards for 1978 and beyond.

TABLE I-2

EMISSION STANDARDS FOR HEAVY-DUTY MOTOR VEHICLES GRAMS/BRAKE-HORSEPOWER HOUR FOR HC & NOx; CO, % OPACITY FOR SMOKE

MODEL YEAR	1975 HC & NOx	1975 CO	1975 SMOKE [1]	1976 HC & NOx	1976 CO	1976 SMOKE [1]	1977 HC & NOx	1977 CO	1977 SMOKE [1]	1978 HC & Nox	1978 CO	1978 SMOKE [1]
NATIONAL	16	40	15, 20, 50	16	40	15, 20, 50	16	40	15,20.50	10 [2]	25 [2]	15,20.35 [2]
CALIFORNIA	10	30		10	30		5	25 [3]		5	25 [3]	

1. Diesel only, lugging, acceleration, peak.
2. Recommended
3. Waiver requested.

TABLE I-3. MAJOR REGULATIONS PROPOSED/PROMULGATED DURING FY 1975

DATE PUBLISHED IN FEDERAL REGISTER	REGULATION	STATUS
July 8, 1974	Regulations for Test Methods to Enforce Lead and Phosphorus Levels for Unleaded Gas	Promulgated
September 10, 1974	Regulations Governing Low-Emission Vehicle Certification for Light-Duty Passenger Vehicles	Promulgated
October 3, 1974	Amendment to Allow EPA to Enter Retail or Distributor Outlets to Test and Sample Gasoline to Determine Compliance with No Lead Regulations	Promulgated
October 18, 1974	Regulations for High Altitude Certification Testing	Promulgated
October 21, 1974	Regulations Requiring Retrofit of Imported Catalyst Equipped Vehicles Driven on Leaded Gasoline	Proposed
October 22, 1974	Regulations for Light-Duty Diesel Truck Emissions	Promulgated
November 12, 1974	Amendment to Require Submission of Information Requested by EPA on the Distribution, Sale, or Delivery of Unleaded Gasoline	Proposed
November 12, 1974	Regulations Requiring Increased Availability of Unleaded Gasoline in Rural Counties	Promulgated
December 23, 1974	Recall Regulations	Promulgated
December 31, 1974	Regulations for Selective Enforcement Audit	Proposed
February 27, 1975	Amendment of Regulations Governing New Gasoline-Powered Heavy-Duty Vehicles	Promulgated
March 5, 1975	Interim Standards for 1977 Model Year Light-Duty Passenger Vehicle	Promulgated
April 25, 1975	Defect Reporting Regulations	Proposed
April 30, 1975	Regulations Governing Certification Procedures for 1977 Model Year Light-Duty Diesel Trucks Offered for Sale in High Altitudes	Promulgated

CHAPTER II. EPA ACTIONS

A. DECISIONS ON 1977 EMISSIONS STANDARDS

On March 5, 1975, the EPA Administrator granted the request of Ford Motor Co., General Motors Corp., and Chrysler Corp. for a 1-year suspension of the HC and CO emissions standards for 1977 model year vehicles. The original standards were applicable to light-duty vehicles and engines manufactured during or after the 1977 model year. In reaching the decision to grant the request, the Administrator considered criteria specified in Section 202(b)(5) of the Clean Air Act (dealing generally with the availability of effective technology, the good faith efforts of the applicants to meet the standards, and the public health and welfare) and information submitted during 3 weeks of hearings.

The Act also directs that if a suspension is granted, EPA must set interim standards representing the best available technology. The Administrator set interim standards of 1.5 grams per mile of HC and 15 grams per mile of CO for the 1977 model year vehicles. The interim NOx emissions standard of 2.0 grams per mile, set July 23, 1973, was maintained.

On the basis of the information submitted during the hearing, EPA determined that the catalytic technology was available for compliance with the 1977 standards. However, the oxidative capability that makes the catalyst effective at converting HC and CO into harmless products also converts contaminant sulfur in gasoline into sulfuric acid.

An accurate model has not been developed to predict the ambient concentration of sulfuric acid that will result in the urban and suburban atmosphere from light duty, catalyst-equipped vehicles. Preliminary and unverified results indicate that under adverse meteorological conditions and traffic concentrations, there is a possibility of potentially harmful ambient levels of sulfuric acid mist along freeways, street canyons, and other facilities which attract a large number of automobiles.

EPA is concerned, therefore, that, as additional model years of catalyst-equipped vehicles are introduced, the potential adverse health effects to sensitive populations from sulfuric acid mist will outweigh the benefits which catalytic converters provide in the reduction of HC, CO, and NOx emissions.

Given these potentialities, the Administrator decided that the Nation's interest would best be served by maintaining the interim standards until the sulfuric acid question is resolved. The Administrator further announced that, if possible, a sulfuric acid emission standard will be issued for the 1979 model year to provide a long term solution to the sulfuric acid problem. In the meantime, EPA is continuing research to substantiate the results of preliminary studies.

With respect to the good faith requirements of the Act, the Administrator noted that the domestic auto manufacturers had reduced their efforts at meeting the statutory standards. However, he pointed out that the industry had developed technology capable of meeting the standards, even though it might not be the best technology, and that the industry is not required to spend more than is necessary to meet the standards. Therefore, he found that the manufacturers had made good faith efforts.

B. WAIVER OF FEDERAL PREEMPTION FOR 1977 MOTOR VEHICLE EMISSION STANDARDS FOR CALIFORNIA

On May 20, 1975, the EPA Administrator granted the request of California to set automobile emission standards for 1977 model year cars that are more stringent than Federal requirements applicable to cars in other areas of the country. Section 209(b) of the Act requires that the Administrator grant such a waiver, after public hearings if he finds that:

- The State requesting preemption requires more stringent standards to meet compelling and extraordinary conditions.

- Such State standards and enforcement procedures are not inconsistent with Section 202(a) of the Act.

On the basis of these criteria and information submitted at a public hearing in Los Angeles, California, on April 29, 1975, the Administrator waived Federal preemption for the 1977 model year and permitted California to set its HC emissions standards at .41 grams/mile, and its NOx standard at 1.5 grams/mile. California did not request a change of its present CO standard of 9.0 grams/mile.

The Administrator found that compelling and extraordinary conditions existed in California. The Air Resource Board testified that the State oxidant pollution problem continues to be the worst in the Nation. The Board presented data demonstrating that the Ambient Air Quality Standard for photochemical oxidants has been violated in the South Coast Air Basin at a substantially greater frequency and at significantly higher concentrations than in any other metropolitan area of the country.

The Administrator also found that technology exists to meet the requested 1977 California standards and that adequate lead time is available to implement the technology. General Motors and Ford agreed that the standard could be met, while Chrysler and American Motors were somewhat pessimistic; all asserted that compliance could be achieved only by paying penalties in the form of high costs, restricted model lines, poorer fuel economy, and reduced driveability.

The Administrator found that two additional factors strengthened the basic conclusion that a waiver of Federal preemption was required:

- "Basic demand" for new cars could be more easily met in California because California sales constitute but 10 percent of the national total; thus greater potential exists for "model switching" -- that is, each manufacturer has a high probability of certifying at least one model in each class of vehicles for California.

- The lead time considerations are not necessarily as severe as the manufacturers stated.

Under California law, manufacturers may delay the introduction of 1977 models until January 1, 1977. This could provide up to four additional months of lead time, depending upon introduction dates presently planned.

The Administrator did not view the issue of whether the proposed California standards would increase emissions of sulfuric acid as a controlling issue in his decision to grant California a waiver, stating that "the structure and history of the California waiver provision clearly indicate both a Congressional intent and an EPA practice of leaving the decision on ambiguous and controversial matters of public policy to California's judgment."

C. MOTOR VEHICLE REGULATIONS

1. Light-Duty Diesel Trucks

Regulations for control of emissions from light-duty diesel-fueled trucks effective with the 1976 model year were promulgated on October 22, 1974 (39 F.R. 37609). Currently, no such vehicles are known to be marketed in the United States although several manufacturers are understood to be planning to market such vehicles.

The standards contained in the regulation are the same as those promulgated for light-duty gasoline-fueled trucks. Manufacturers are not expected to use special emission control devices or add-on equipment to meet the standard. Hence, the only additional cost to the manufacturer will be the cost of certification. The cost per truck cannot be estimated at this time due to lack of projected sales data.

2. Light-Duty Diesel Trucks in High Altitudes

Regulations for control of emissions from light-duty diesel trucks designed for initial sale at high altitudes, effective with the 1977 model year, were promulgated on April 30, 1975 (40 F.R. 18778). High altitude is defined as any elevation over 1219 meters (4000 feet). These regulations are consistent with the high altitude regulations for light-duty gasoline-fueled trucks, light-duty gasoline-fueled vehicles, and light-duty diesel-powered vehicles.

The standards are expected to be met without additional hardware or tooling costs, so the only additional cost will be for certification. Lack of data on projected sales for light-duty diesel trucks at high altitudes prevents the estimation of the additional cost per truck at this time.

3. 1977 Model Passenger Vehicles in High Altitudes

Regulations for control of emissions from light-duty gasoline-fueled vehicles, light-duty diesel vehicles, and light-duty trucks intended for initial sale at high altitudes, effective for the 1977 model year, were promulgated on October 18, 1974 (39 F.R. 37299).

In order to meet the standard, manufacturer's costs will increase from $4 to $19 per affected vehicle, depending upon the method of emission control.

4. Exhaust Emission Standards for Hydrocarbons

EPA is analyzing comments received in response to an Advance Notice of Proposed Rulemaking (ANPRM) which would convert the current hydrocarbon exhaust emission standard from a total to a nonmethane hydrocarbon basis. The ANPRM (39 F.R. 16904) was published in response to a Ford Motor Co. petition which stated that catalyst-equipped vehicles tended to have a greater proportion of methane (a nonreactive and thus nonpolluting hydrocarbon) in the exhaust than current vehicles. Therefore, Ford Motor Co. reasoned that an emissons standard based on all hydrocarbons, including methane, penalized vehicles with catalysts.

Emission control systems which selectively remove more reactive hydrocarbons could more easily meet an emission standard based only on reactive hydrocarbons. Advanced systems (for example, dual catalyst) would be affected most directly by the regulations, especially if all hydrocarbons considered to be nonreactive (methane, ethane, propane, benzene, and acetylene) were excluded.

Implementing a reactive hydrocarbon emission standard for mobile sources would require both development of measurement instrumentation and extensive testing of 1970 model vehicles to revise the baseline against which the required 90% reduction in emissions is measured. This effort would require at least 3 years. A revised emission standard which excluded methane only and applied only to light-duty vehicles could be implemented somewhat sooner, but would yield approximately half the benefits mentioned above.

5. Certification of Low-Emission Vehicles

Revised regulations for certification of low emission vehicles under Section 212 of the Clean Air Act were promulgated on September 10, 1974 (39 F.R. 32613).

Section 212 of the Clean Air Act provides for the creation of a Low Emission Vehicle Certification Board (LEVCB). Upon submission of an application, the EPA Administrator must determine whether a vehicle qualifies as having emissions substantially lower than standard levels. If so, LEVCB then must certify that a vehicle is suitable as a substitute for any class of vehicles then in use by the Federal Government. Certified vehicles may be purchased by the Government at premiums ranging up to 100 percent over prices normally paid for equivalent vehicles.

At a meeting on December 2, 1974, however, the LEVCB concluded that Section 212 in its present form is not likely to result in certification of any low emission vehicles or to achieve the objectives envisioned by ts drafters.

Accordingly, the EPA Administrator (Chairman of LEVCB) sent to Senator Edmund S. Muskie, Chairman, Subcommittee on Environmental Pollution, Committee on Public Works, a letter containing these recommendations:

- The Subcommittee may be well advised to eliminate Section 212 from the Clean Air Act (Alternative 1). Federal agencies able to integrate electric vehicles into their operations can already do so without obtaining Section 212 certification.

- If the Subcommittee concludes that there should be a Federal program to introduce electrically powered vehicles, a program much less cumbersome than that set up by Section 212 should be employed.

One approach would be to simply authorize funds for the General Services Administration (GSA) and other Federal agencies to use at their discretion to cover the added costs of procuring electrically powered vehicles. GSA advises that to implement such a program it would be necessary to waive the statutory price limitations imposed by Public Law 93-381 on purchase of sedan-type vehicles.

6. Importation of Catalyst-Equipped Vehicles

EPA has proposed an amendment to the regulations governing the importation of motor vehicles and motor vehicle engines (Subpart P, Part 85 of Title 40 of the Code of Federal Regulations). The purpose of the amendment is to assure that vehicles equipped with catalytic converters, driven abroad on leaded gasoline, and later imported into the United States are brought into conformity with U.S. emission standards. This is necessary because lead poisons the catalyst and adversely affects emission reduction.

The amended regulations prohibit the importation of catalyst-equipped vehicles which have been operated outside the United States, Canada, and Mexico unless the vehicle is:

- Part of a catalyst control program implemented by the vehicle manufacturer and approved by EPA. This program will ensure that a poisoned catalyst is replaced following importation.

- Part of a catalyst control program developed and administered either by the State Department and the Department of Defense for their own personnel.

- Entered conditionally under bond posted by the importer (generally an individual consumer). The vehicle and duty bond are released once a new catalyst is installed.

Manufacturers with control programs have incorporated them within existing service programs and estimate the cost to be nominal. An importer of a car requiring a catalyst change will pay $75 for a pellet catalyst and $150 to $200 for a monolithic catalyst.

7. Recall

On December 23, 1974, EPA promulgated regulations effective January 22, 1975 requiring that a manufacturer, following notification by the Administrator that a substantial number of his vehicles do not conform to emissions standards or regulations, submit a recall plan to the Administrator (39 F.R. 44369). Further actions relating to these regulations are discussed in Section II-F-2.

8. Reporting of Defects

On April 25, 1975, EPA proposed regulations requiring manufacturers to report information concerning any emission-related defects they discover. Each manufacturer would then be required to provide EPA with advance notice of his plans to remedy such defects.

The Defect Reporting Regulations are designed around the systems already employed by the industry to identify safety-related defects as required by the National Highway Traffic Safety Administration. The proposed regulations do not require a manufacturer to establish a program to locate emission-related defects but require him to report both the defects he discovers and his voluntary repair efforts as well.

D. SELECTIVE ENFORCEMENT AUDITING

Under Section 206 of the Clean Air Act, EPA proposes to test new motor vehicles at the assembly line to determine if they conform with regulations under which their Certificate of Conformity was issued. Under the program, called the Selective Enforcement Audit (SEA), EPA will issue an administrative order requiring that a manufacturer select and test certain production vehicles. If the test results indicate a violation of the Certificate of Conformity, EPA may revoke it. SEA regulations were proposed in December, 1974. Regulations are scheduled to be promulgated in FY 1976 after a public hearing.

E. CERTIFICATION AND SURVEILLANCE PROCEDURES

1. Certification Testing

Certification of new passenger cars for compliance with Federal emission standards began with 1968 model year vehicles. The program includes testing of prototype vehicles which represent all new motor vehicles sold in the United States.

EPA requires the manufacturer to submit data from two tests. First, through the Emissions Fleet Test, prototype fleets are tested at 4000 miles to determine their emissions levels at close to the "break in" point. Second, through the Durability Fleet Test, fleets are tested at 5000 mile intervals to 50,000 miles to determine the deterioration of the emission control system. To check manufacturers' data, EPA can and does require that a vehicle being tested be brought to the EPA laboratory in Ann Arbor, Mich., for confirmatory tests. Approximately 2200 such confirmatory tests were conducted by EPA during the period covered by this report.

During FY 1975, certification of most 1975 model year light-duty vehicles and light-duty trucks was completed, and certification of 1976 models began. Approximately 50 manufacturers of light-duty vehicles and trucks applied for certification of about 315 engine families for the 1975 model year. Approximately 240 certificates of conformity were issued. The two major reasons for engine families not receiving certification were withdrawal of application and failure to meet certification standards.

A significant development during the 1975 model year was the certification of approximately 160 engine families equipped with catalytic converters. These families correspond to about 85% of anticipated sales of light-duty vehicles.

In addition to the requirements for original certification of motor vehicles, EPA has regulations governing vehicles and engines changed during production of new models. Approximately 2000 requests for change in new models were reviewed, and more than 650 tests were conducted to determine compliance with standards.

Certificates are also issued to cover gasoline-fueled and diesel heavy-duty (truck-type) engines. In this segment of the industry, approximately 1,000 emission tests were performed by 25 manufacturers. EPA monitored the test programs to ensure program integrity. After the emissions testing, over 100 Certificates of Conformity were issued. Approximately 300 requests to make changes during mass production of new engines were processed.

In conjunction with the Federal Energy Administration, EPA published fuel-economy data in "The 1975 Gas Mileage Guide for New Car Buyers." These data include fuel economy results from EPA testing of emission certification prototypes. Cold start, city cycle testing began with 1973 model year vehicles. A hot start, highway cycle was added with the 1975 model year. Both agencies also sponsored a voluntary fuel economy labeling program for new cars.

2. Inspections/Investigation Program

EPA schedules periodic audits of certification procedures used by vehicle manufacturers and inspects facilities to ensure that certification procedures are being observed. Also, vehicle assembly plants are inspected to ensure that new vehicles are assembled in certified configurations. In the past year, EPA conducted 43 in-depth inspections of vehicle manufacturer and assembly plants. EPA's inspection team visited 11 foreign manufacturers, all four major domestic manufacturers, and 12 low-volume manufacturers.

During the past year, EPA also initiated seven investigations of potential Clean Air Act violations by manufacturers and made one referral to the Department of Justice.

3. Surveillance Testing

Two kinds of tests were performed on vehicles in use during FY 1975. The first, known as the FY 1973 Emission Factors Program involved the testing of 1080 vehicles "as received" in six cities. Its purpose was to determine the emission levels of autos as they are actually maintained by their owners.

The second, known as the FY 1973 In-Use Compliance Program, involved the testing of 1385 well maintained vehicles after a tune-up to manufacturer's specifications. The purpose of these tests was to determine the capability of properly maintained autos to meet the emission standards for which they were certified.

The results of those two test programs indicate that properly maintained 1973 and 1974 model cars meet their certification emission standards on the average; however, 1973 autos, as actually maintained by their owners do not. Tables II-1 and II-2 show that the amount by which the average automobile exceeds its design standards is small for relatively new cars, and, as shown by the 1967-1974 average, increases with age or mileage.

Table II-1

FY 1973 EMISSIONS AND COMPLIANCE TESTING OF VEHICLES AT LOW ALTITUDES 1/

		EMISSION LEVELS, grams/mile		
		HC	CO	NOx
Precontrol		8.7	87	3.5
As maintained by owners	1967-74 2/	5.0	61	4.3
	1972	4.1	54	4.6
	1973	3.6	45	3.4
	1974	3.0	36	2.8
After a tuneup to manufacturer's specifications	1973	2.8	28	2.8
Federal Emission Standards 3/	1972-1974	3.0	28	3.1

1/ Below 4000 feet
2/ Average
3/ Approximately equivalent standards. Actual emission standards based on a different test procedure.

Table II-2

FY 1973 EMISSIONS TESTING OF VEHICLES AT HIGH ALTITUDES 1/

MODEL YEAR		EMISSION LEVELS, grams/mile		
		HC	CO	NOx
Precontrol		10.2	127	1.9
As maintained by owners	1967-1974	6.2	99	2.9
	1972	5.4	91	3.3
	1973	4.5	85	2.0
	1974	4.2	79	1.8
Federal Emission Standards	1972-1974 2/	3.0	28	3.1

1/ Above 4000 feet
2/ Approximately equivalent values. Actual emission standards determined by different test procedure.

F. OTHER EPA PROGRAMS

1. Antitampering Program

Section 203(a)(3) of the Clean Air Act prohibits any manufacturer or dealer from knowingly removing or rendering inoperative a vehicle's emission control system following sale of the vehicle to the ultimate purchaser. During the past year, 15 investigations of potential violations of the tampering prohibition were conducted. Five new cases were referred to the Department of Justice for action. The referrals resulted in prosecutions of four car dealers for removal of emission control systems; $5700 in fines were collected. EPA is continuing to urge enforcement of State antitampering statutes, which are applicable to most commercial auto repair businesses. Approximately 40 states have antitampering laws, but few are actively enforced.

EPA conducted surveys to determine whether tampering is a significant problem (Table II-3). The surveys, conducted in cooperation with State and city motor vehicle departments, consist of a visual check of the emission control systems of vehicles as they pass through annual inspection. The results indicate significant tampering.

To encourage mechanics to refrain from tampering with emission control systems, EPA has emphasized the development of training courses for emission control tuneup. To aid investigators on tampering cases, EPA has updated its "Inspectors Guidebook" to include a pictorial display of emission control systems of 1974 and 1975 domestic and foreign vehicles.

Table II-3

RESULTS OF ANTITAMPERING SURVEY CONDUCTED BY EPA

SURVEY AREA	% of vehicles with major components of emission control system removed	% of vehicles with missing air/fuel limiter caps 1/
Washington, D.C.	15	33
New Jersey	15	50
Cincinnati, Ohio	2/	17

1. Suggests degradation of emission control through poorer control of air-fuel mixture.
2. Not available.

2. Recall Program

Section 207(c) of the Clean Air Act requires the EPA Administrator to notify a manufacturer to recall and repair vehicles of a given type when the Administrator determines that a substantial number do not conform to applicable emission standards during their useful lives. The objective is to provide incentives to manufacturers to build vehicles which conform with emission standards for 5 years or 50,000 miles of actual use. The recall program consists of surveillance and investigation, recall order implementation, and public reporting.

Surveillance is comprised of Federal in-use vehicle testing, defects reporting from government and commercial fleets, review of data from State and local inspection/maintenance programs, other emission test results, consumer complaints, and manufacturer's defects reporting.

As a result of surveillance activity during part of FY 1975 12 manufacturer initiated recalls and one ordered campaign were completed; 428,558 vehicles were affected. To date 1,514,933 vehicles have been recalled to correct emission-related nonconformities. Twelve investigations initiated in FY 1975 are continuing.

Public reporting of recall campaigns instituted under the Clean Air Act will be initiated in FY 1976. By issuing periodic reports of emission recall campaigns, EPA hopes to establish communication with the public on the compliance of in-use vehicles with the Clean Air Act. Not only will the public receive valuable information on the vehicles subject to recall, but, through exposure to the existence of such campaigns, public participation will be encouraged as well.

3. Imports Program

In conjunction with the U.S. Customs Service, EPA monitors imported vehicles to ensure that they conform with U.S. emission standards. Those not conforming may be imported under a U.S. Customs bond pending modification of the vehicle to meet the standards. Vehicles that can not be modified to conform must be exported or destroyed.

EPA periodically vists Customs ports in the United States to inspect imported vehicles, and to meet with customs officials concerning enforcement of the joint EPA-Customs regulations. During the past year, EPA made at least one visit to 36 ports of entry in the United States. EPA monitored entry of approximately 200,000 commercial and privately owned vehicles, issued orders which resulted in 314 vehicles being modified to conformity and exported 68 nonconforming vehicles. 152 vehicle owners were penalized by Customs in the amount of approximately $411,000 for not complying with the joint EPA-Customs regulations.

EPA initiated 80 investigations of potential violations of the import provisions of the Act. One of these cases was in referred to the Department of Justice. In some of the remaining cases, Customs was requested to assess civil penalties against the vehicle owners.

4. Aftermarket Parts Program

On November 14, 1974, EPA published in the Federal Register an Advance Notice of Proposed Guidelines describing a program of voluntary self-certification for manufacturers of automotive parts for replacement of defective or worn-out emissions control systems. The proposed aftermarket parts program will attempt to develop certification standards that will enable manufacturers to design and build their parts in conformity with the standards. The manufacturer would then be able to advertise the aftermarket parts as being on a par with the original equipment they replace. The program is intended to help alleviate any adverse competitive impact of the emission control warranty by providing an objective basis for ensuring that after-market parts do not degrade performance. EPA is working closely with the aftermarket industry to develop acceptable procedures for testing.

5. Fuels Program

In order to protect catalytic converters from debilitating contamination caused by lead in gasoline, EPA is authorized under Section 211 of the Clean Air Act to regulate the lead content of gasoline to be used in catalyst-equipped vehicles.

EPA has established a field sampling inspection system to assure the general availability of lead-free fuel at the retail outlet. Each of EPA's 10 Regional Offices has a mobile fuels test laboratory to sample and test lead-free gasoline at the retail outlets. All tests indicating contamination, plus 10% of all field samples, are sent to the laboratory. A control program has been implemented to monitor the quality of laboratory and field analyses. Each Region inspected 1,000 to 2,000 retail outlets during FY 1975. In total, 17,000 samples of unleaded gasoline were collected and analyzed by EPA personnel. In addition, more than 3,649 notices of violation were issued for minor violations and over 300 formal complaints assessing penalties issued for more serious problems.

States are being encouraged to sample lead-free gasoline and to adopt lead-free gasoline regulations. During FY 1976, at least seven States will inspect unleaded gasoline under contracts with EPA.

6. Warranties Program

Section 207(a) of the Clean Air Act provides for a defects warranty starting with the 1972 model year. The warranty provides that when through no fault of the owner, an automobile fails to comply with applicable emissions standards, the manufacturer must remedy such nonconformity and bear the costs. EPA has concluded that consumers do not understand this warranty, which is contained in all owner's manuals, and, therefore, are making few claims under it. To overcome this difficulty, EPA will soon publish an Advance Notice of Proposed Rulemaking (ANPRM). ANPRM includes two lists -- a "defects" list and an "emissions control system" list. Defects (specified failure modes of specified emissions-related parts) would be presumed to cause emission standards to be exceeded and would thus be covered by the warranty. The emissions control system list would include all parts which, if they fail, could potentially cause the vehicle to exceed standards and thus be covered by the warranty. Under regulations proposed in this ANPRM, EPA intends to monitor the vehicle manufacturers' efforts under the warranty.

The 207(b) performance warranty of the Clean Air Act, running from initial to ultimate purchasers cannot be implemented until EPA develops a short test which reasonably correlates with the sophisticated Federal Test Procedure used on prototypes of new vehicles. At the present time EPA is continuing its efforts to develop a short test and has set as a target date for implementation the 1978 model year.

7. Inspection/Maintenance

Inspection/Maintenance (I/M) of in-use vehicles is intended to cause the public to realize more fully the benefits of the emission controls installed on their vehicles. The program consists of either measurement of emissions while the car is running in neutral or a dynamometer test which measures emissions during a simulated short driving cycle. Development work for the program began in 1971 with EPA studies undertaken to determine the emission reductions associated with State Implementation Plans pursuant to Section 110 of the Clean Air Act. I/M programs are required in 28 areas of the country as part of a State Implementation plan for meeting auto related primary standards. Seven States (or local areas) have programs either underway or nearly underway. Seven notices of violation have been issued to jurisdictions failing to take steps necessary to implement I/M programs. Implementation is expected to increase in the future as institutional steps necessary to implement the program (legal changes, construction of facilities, etc.) are accomplished.

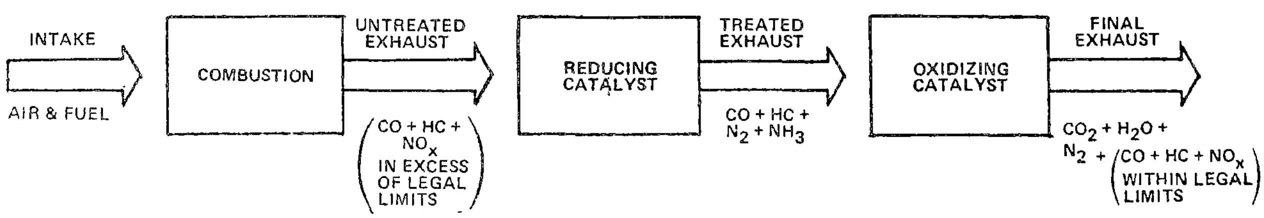
CHAPTER III. PROGRESS IN EMISSION REDUCTION TECHNOLOGY

A. CATALYST TECHNOLOGY

Several types of catalytic converters are presently in use or under development. The oxidizing catalytic converter, a device in the exhaust stream which stimulates oxidation of unburned fuel, changes HC and CO emissions into harmless carbon dioxide (CO_2)and water. The reducing catalytic system stimulates conversion of NOx into nitrogen gas (N_2).

These two converters can be combined in a dual-bed system. Figures 111-1). In such a system, the exhaust first passes through a reducing catalyst where NO_x is transformed into N_2 and small amounts of ammonia (NH). The exhaust then passes through an oxidizing catalyst where CO and HC are changed into CO and H_2O, and the small amounts of ammonia are oxidized to NO_x

Figure III—1. Operation of a Dual-Bed Catalyst



The final basic catalytic system is the three way catalyst in which HC, CO, and NOx are converted in one catalyst bed.

A problem with the widespread use of present catalyst systems is that they may emit sulfuric acid in concentrations that are projected to be a possible threat to the public health. For this reason, EPA contracted with Exxon Research and Engineering Co. to investigate various means for control of sulfuric acid emissions from catalyst-equipped motor vehicles. The most promising technology to date is the three-way catalyst reformulation (using different metals in the catalyst), combined with the control of excess air in the catalyst. Widespread use of the three-way catalyst is not expected to be feasible until 1979-80, due to the long production lead times required for the very precise fuel metering needed with these systems. In addition, the durability of these systems continues to require investigation.

Exxon also identified chemical traps using a calcium-oxide-based absorbent as a potentially effective sulfuric acid and sulfate control method; the initial design tested by Exxon revealed, however, that with extended use, the trap when properly placed in the exhaust line, tended to restrict exhaust flow and, therefore, resulted in increased exhaust back pressure. This increase is undesirable because of its effect on overall engine efficiency. Further research and development are needed if a satisfactory trap is to be produced.

Other problems accompanying the widespread use of catalytic convertors include objectionable odors and the possibility of overheating or fires. The primary odorous material is believed to be hydrogen sulfide, formed in the catalyst from sulfur in the gasoline, usually during engine idling conditions, when the air-fuel mixture in the carburetor has become too rich. Vehicle manufacturers have informed EPA that these odors should be eliminated if the carburetor is adjusted within the manufacturers' specified limits and other sources of rich mixtures (clogged air filter) are repaired.

With respect to catalyst overheating, the information available to EPA indicates that if the engine is running properly catalyst surfaces are no hotter than surfaces of exhaust systems containing no catalyst. However, if there is a partial failure of the ignition system, such as misfiring spark plugs, catalyst temperatures may rise to over 1200 F because of the abnormal amount of fuel delivered to it by the non-firing cylinders. In most catalyst-caused fires reported to EPA, the vehicles involved have been found to be running badly.

Currently, EPA is cooperating with the U.S. Forest Service to evaluate the possibility that vegetation fires in the National Forests and Parks are caused by hot exhaust systems, both catalytic and noncatalytic. In addition, EPA is cooperating with the National Highway Traffic Safety Administration in obtaining information as to measures being taken by the manufacturers to minimize the likelihood that vehicles equipped with catalysts will increase fire hazards. Further, EPA has publicly urged that vehicle manufacturers install temperature sensors on their catalysts which will activate lights and buzzers to warn the driver that the catalyst has overheated. Such devices may not only reduce fire hazards, but could, in addition, save fuel and control emissions better since higher-than-usual catalyst surface temperature usually indicates engine malfunction.

Less than optimal control of the basic engine operating parameters (especially air-fuel mixture control) has, in the past, led to catalyst deterioration, attrition (loss of catalyst material), and formation of ammonia. Refinements in reduction catalysts and dual catalyst systems have, however, resulted in catalyst systems with greater tolerance for less than ideal operating environments. In one such refinement, developed by Gould Inc., an oxygen removal catalyst or "getter" is added to Gould's metallic dual catalyst system; this eliminates the occasional overly lean mixtures (too great a percentage of air in the air-fuel mixture) that cause deterioration of the NOx catalyst itself. By controlling air-fuel mixture in this way, catalyst-engine matching has been significantly improved. The Gould system has demonstrated NOx levels close to 0.4 during durability tests of over 25,000 miles. When used in conjunction with advanced engine modifications and exhaust gas recirculation systems, (see §III-3), certification to the statutory 0.41/3.4/0.4 levels may be possible, provided the catalyst is changed at 25,000 miles. An unresolved issue with the Gould system is particulate emissions. Preliminary data suggest some attrition or loss of metal in the nickel-based catalyst is occurring when cars equipped with the Gould system are run on gasoline containing moderate amounts of sulfur. Additional testing is necessary to assess the extent of this potential problem.

Catalyst-engine matching has also been significantly improved by feedback control systems that closely control air fuel ratios. Oxygen sensors, which respond to excess oxygen in the exhaust gases, can signal the carburetor or the fuel injection system to control the ratio. To date, fuel injection systems have provided the most rapid and accurate response. When the excess oxygen in the exhaust is closely controlled by a feedback system, it is possible either to extend the life and efficiency of a NOx catalyst, or to convert simultaneously HC, CO, and NOx in one catalyst bed (three-way catalyst).

Prototype exhaust sensors with 20,000 mile life and modest ($5) replacement costs are now available. Two problems remain with the feedback approach:

- No three-way catalyst has yet been able to maintain 0.4 NOx levels at high mileage in a standard vehicle.

- The costs of fuel injection systems are much greater than the costs of carburetors, and U. S. manufacturers are hesitant to bear this added cost in addition to the already increased costs of other necessary emission controls.

Even if the durability problems with reducing or three-way catalysts are solved, it appears that the cost of any technology capable of meeting the 0.4 NOx standard will be high. Initial costs are estimated to range between $350 and $550 for systems meeting the full statutory standards, compared to estimated costs of $200 for the typical 1975 oxidation catalyst system.

B. <u>"Lean Burn" Technology</u>

Engines calibrated for very lean air fuel ratios achieve low emissions of CO, HC, and sulfuric acid even without a catalytic system. An advanced form of "lean burn" technology would utilize various sensors, including an oxygen sensor, a mini-computer, and feedback circuits to optimize spark timing, exhaust gas recirculation rate, air-fuel ratio, and transmission shift points. These improvements might cost no more than present catalyst technology and would control emissions to the 1975 California levels (0.9/9.0/2.0) with little or no fuel economy decrease compared to uncontrolled cars. However, to achieve emissions much below these levels, a catalyst will most likely be needed in conjunction with some or all of the "lean burn" system components. At present, one domestic manufactuer is actively considering full scale production of lean burn type vehicles.

The Dresser carburetor is one of the major developments in air-fuel mixture control. Its primary application to date is in lean burn engine systems, although it is compatible with other systems. It achieves a high degree of fuel atomization by use of high speed air flowing through a variable area venturi. The Dresser system produces an unusually homogeneous air-fuel mixture. This overcomes much of the cylinder-to-cylinder variation in air-fuel ratio which hampers current attempts to operate engines with very lean air-fuel mixtures. The Dresser carburetor's ability to control air-fuel ratios may enable it to be used with three-way catalysts, thus providing an alternative to expensive fuel injection systems.

C. Exhaust Gas Recirculation

Recirculating exhaust gas through the intake system controls NOx emissions by reducing the peak combustion temperature. The exhaust gas, an inert substance, does not contribute to the combustion process. Refinements have been made in the laboratory to exhaust gas recirculation (EGR) systems, with the most significant recent work being that of Gumbelton.1/ He reported an EGR system which resulted in 1.0 gpm NOx levels from full size cars without fuel economy penalties. However, the conditions that promote low NOx emissions also promote high HC emissions. Achieving low NOx emissions control can increase HC emissions to the point that 0.41 HC standard becomes tougher to meet than the .4 NOx standard.

It is clear that optimum EGR operation will require more sophisticated systems than are available on current cars. Work on electronically modulated EGR and spark timing systems has been reported as encouraging in the laboratory, but there have been no commitments to produce such systems.

D. Questor System

The "Questor" system combines high temperature oxidation of HC and CO with catalytic reduction of NOx and has shown considerable potential for achieving the 0.41/3.4/0.4 standards. In tests (on standard size cars) by several manufacturers, emissions were reduced below the standards. Problems remain, however, with the degree of mixture enrichment required and high temperatures necessary to achieve adequate control of HC, CO, and NOx. The rich mixtures used with the Questor system increase fuel consumption and exhaust temperatures, which degrade the system with use. Over 3 years, however, the fuel economy associated with the Questor system has been improved to a position of parity with 1974 models (13% lower than 1975 models).

E. Alternative Engines

Several alternatives to the conventional internal combustion engine are under development and may have some bearing on emissions in the next few years.

The stratified charge engine employs a layered fuel mixture in the combustion chamber. The idea is to keep a fuel-rich mixture near the point of ignition inside the cylinder while keeping the rest of the mixture lean.

Honda's CVCC stratified charge engine uses a small-volume, fuel-rich prechamber at the fuel ignition point, with the main combustion chamber containing a fuel-lean mixture. The CVCC principle has been shown capable of bringing even full size cars into compliance with 0.41/3.4/2.0 levels with essentially no increase in fuel consumption over average 1975 cars. Using spark retard and EGR, NOx can be lowered to 0.25 on small cars providing adequate cushion to meet a 0.4 standard. A problem at this calibration level is fuel consumption which, in the initial testing, was increased by about 20%.

Ford's Proco stratified charge engine employs an open combustion chamber differing from the Honda prechamber system. The Proco can achieve 0.4 NOx in 4500-pound cars without catalytic control of NOx because of the combination of stratified charge combustion and high EGR. HC emissions, rather than NOx have presented the greatest problem. While the Proco vehicle can simultaneously achieve 0.41/3.4/0.4 with oxidation catalysts, HC levels have exceeded 0.41 prior to 25,000 miles at the 0.4 NOx calibration. In an uncontrolled state, the Proco engine uses substantially less fuel than conventional engines, but it has high HC emissions. Reducing HC levels has so far required throttling, which makes the engine's fuel consumption comparable to conventional engines. Once throttling is used to control HC emissions, further measures, such as EGR to lower NOx, have little effect on fuel consumption. At present, there are no production versions of the Proco engine.

The rotary engine uses rotating drive elements to replace the reciprocating pistons currently used in internal combusion engines. Toyo Kogyo has made major improvements in control technology for engines in the past 5 years. Current stratified-charge rotary engine prototypes show potential for meeting the 0.41/3.4/0.4 standards. Prototypes have achieved 0.33/1.7/0.38, while consuming less fuel than current 1974 and 1975 production versions of the engine.

Diesel engine passenger cars currently produced by several manufactuers show potential for meeting the 1978 standards. Greater use of diesel engines in passenger cars continues to be studied by industry. At this time, it appears that diesel-powered passenger cars can be designed to achieve emission levels of 0.41 HC and 3.4 CO, with NOx levels in the range of 1.0 to 1.5. The prospects for meeting 0.4 NOx with a diesel automobile are not known, due to limited developmental efforts, but are considered unlikely.

During the period covered by this report, the Federal program on alternative automotive power systems, was transferred to the new Energy Research and Development Administration. The projects on Rankine cycle, gas turbine, and Stirling cycle engines started under EPA will be redirected and in some cases expanded in response to the energy conservation mission of that agency. While these systems continue to offer long-term potential for meeting very low emission standards, their large-scale manufacture will be later than any of the other systems discussed here--certainly post-1980.

CHAPTER IV. COSTS AND BENEFITS OF MEETING EMISSION STANDARDS

A. COSTS OF MEETING EMISSIONS STANDARDS

1. Passenger Vehicles

a. Emissions Control Equipment, 1976 Model Year

Because the 1976 emissions standards are the same as the 1975 interim levels, only minor changes in control systems will be made from 1975 models and, thus, no increased cost is attributed to the 1976 model year emission control equipment. Estimates of the equipment or engine modification costs per car for 1976 emissions control equipment over baseline (pre 1968) vehicle costs are:

- EPA -- $200
- NAS -- $159
- Industry -- $100 - $450

b. Emissions Control Equipment, 1977 Model Year

With the suspension of the statutory 1977 emissions standards, the automobile manufacturers should be able to meet the interim 1977 standards with minor engine and control device modifications.

The interim standards are the same as the 1975/76 standards for HC and CO. The 1977 standard of 2.0 grams/mile NOx is 35 percent lower than 1975/76 level. The needed engine modifications could take the form of improved EGR systems. EPA estimates that the incremental cost of meeting the 1977 standards is $20 per vehicle.

c. Emissions Control Equipment, 1978 Statutory Standards

Additional technology will be required to meet the full statutory Federal emission standards. Systems which involve modification of conventional internal combustion engines have shown capability of meeting the 1978 standards at low mileage. Dual and three-way catalysts are considered the most advanced of the systems being investigated. Estimates of the cumulative initial costs of meeting the 1978 standards are:

- EPA -- $470
- NAS -- $304
- Industry -- $315 - $950

Table IV-1 summarizes the estimated cost of meeting the emissions standards for 1968-1980 model years. For 1979 and 1980, the incremental cost of added emission control equipment is expected to be minimal.

TABLE IV-1. ESTIMATED COSTS FOR EMISSION CONTROL EQUIPMENT, PASSENGER VEHICLES

	List price 1/	(December 1974 dollars)	
Model year standards	EPA 2/	NAS 2/	Industry 3/
Cumulative costs through 1974	100	84	50-120
1975/76 incremental costs	100	75	50-330
1978(full statutory standards) incremental costs	20	-- 4/	-- 4/
1978 incremental costs	250	145	215-500
Cumulative costs through 1980	470	304 5/	315-950 5/

1/ Includes dealer and factory profits.
2/ Data obtained primarily from "Automobile Emission Control--The Technical Status and Outlook as of December, 1974", a Report of the EPA Administrator, January 1975.
3/ Data submitted by domestic manufacturers.
4/ Data not available.
5/ Includes a "zero" value for data not available in 1977.

d. Maintenance

Maintenance costs for emissions control systems are expected to fluctuate for 1975-1980 model vehicles. The increasing complexity of the systems will cause increased maintenance costs. There are, however, certain benefits in reduced maintenance cost derived from the use of high energy ignition systems, increasingly durable exhaust systems and unleaded fuel.

Changes in annual maintenance cost for the various model years are shown in Table IV-2.

TABLE IV-2. ESTIMATED MAINTENANCE COSTS DUE TO EMISSION CONTROL SYSTEMS, 1968-1980 PASSENGER VEHICLES

	Changes in annual maintenance cost per vehicle
1968-1974	+$16
1975-1977 [1]	-$7 (December 1974 dollars) [2]
1978-1980	+$6 (December 1974 dollars) [3]

1/ Assuming that 85% of vehicles sold in 1975 will be catalyst equipped, 80% in 1976, 75% in 1977.

2/ Assuming oxidation catalysts used all three years and based on standards of 1.5 HC, 15C0, 3.1 NOx (1975-76 models); 2.0 NOx 1977 models.

3/ Assuming use of oxidation catalysts and based on statutory standards of 0.41 HC, 3.4 CO, and 0.4 NOx.

Source: The Cost of Clean Air 1975--Annual Report of the Administrator, 1975, unpublished draft.

e. Fuel Economy Penalties

The average fuel economy of motor vehicles has decreased gradually over the past few years (up to 1974 model vehicles). This decrease is due in part to vehicle weight and optional equipment, but emissions control mechanisms such as EGR and retarded ignition timing also adversely affect fuel economy.

Fuel penalties for the 1968 model years are obtained from an EPA study of nearly 4,000 passenger cars, from 1957 production models to 1975 prototypes. For 1973 model cars economy decreased 10.1 percent over pre-1968 cars. For the 1974 models, fuel economy decreased 10.4 percent over the pre-1968 baseline, based on estimates from 1974 certification data and sales data for the first 6 months. A shift toward lighter cars was observed in the first 6 months' sales, but the trend was reversed for the remainder of the year.

Industry sources as well as EPA, have indicated that fuel economy on vehicles equipped with catalysts increased compared to 1973 and 1974 model year cars. When weighted for estimated sales, EPA's 1975 vehicle certification data showed a increase in economy of approximately 1 percent over pre-1968 cars.

An additional fuel savings, of about 12 percent compared to 1975 MY cars, is anticipated for the 1976 model year. No change from 1976 figures is expected for the 1977 model year. However, meeting the full statutory standards would mean that fuel economy may decrease 15-20 percent compared to 1976 MY cars, in the first year of implementation. This fuel economy loss would be due primarily to the stringent NOx emission control standards, for which control technology has not yet been demonstrated. In subsequent years, as emission control technology is further refined, it is probable that the fuel penalty will be reduced to the point of 1976 levels.

These estimates of future fuel economy note only the changes due to emission controls. Separate industry efforts to improve fuel economy, such as reduction of size and weight and improvement of engine efficiency, will increase fuel economy of all affected models.

The effect of emission controls on passenger-car fuel economy for the period 1968 to 1970 is summarized in Table IV-3.

TABLE IV-3. EFFECT OF EMISSION CONTROLS ON FUEL ECONOMY OF PASSENGER VEHICLES

Model Year Standards	Yearly Incremental change in fuel economy, percent	Fuel economy penalty over baseline, percent 1/
1957-67 (Uncontrolled)	--	--
1968	- 4.2	4.2
1969	- 1.9	5.9
1970	+ 2.4	3.9
1971	- 2.4	5.9
1972	- 1.5	7.3
1973	- 3.0	10.1
1974	- 0.3	10.4
1975	+ 13.5	-1.7
1976	+ 12.0	-13.9
1977	0.0	-13.9
1978	- 15 to 20%*	3.2-8.9*

1/ Baseline city fuel economy of 1967 model year car = 13.5 miles/gallon. All percentages shown are based on Urban Cycle Fuel Economy tested on the 1975 EPA Federal Test Procedure.

Source: Office of Mobile Source Air Pollution Control, March, 1976 data.

* Statutory standards in effect for 1978 as of June 30, 1975 were 0.41 HC, 3.4 CO, 0.4 NOx (all gm/mi.). Standards being reconsidered by Congress; any modification will affect fuel economy of all vehicles.

f. Light-Duty Trucks

For this report, emission control equipment costs for 1973 and 1974 model year light-duty trucks (under 6,000 pounds gross vehicle weight) are assumed to be the same as for passenger cars for 1973 and 1974--that is, $87 per car in current dollars. Standards less stringent than those for passenger vehicles were set for light-duty trucks beginning with the 1975 model year; consequently, it is assumed that emission control costs for model years 1975-1980 will be only moderately higher than for the 1973-74 years ($150 per car in December 1974 dollars).

Annual incremental maintenance costs for emission controls on 1973 and 1974 model year light-duty trucks are estimated to be $16 per vehicle. For the 1975 to 1980 model years maintenance cost will decrease an estimated $10 per vehicle due to the use of catalysts, low-maintenance emission-control components, and unleaded fuel in a significant portion of light-duty trucks sold.

Fuel economy of light-duty trucks is expected to be the same as for light-duty passenger cars for 1973 and 1974. Fuel consumption is estimated to decrease 6 percent for the 1975 model year, and no further emissions related change is expected for the 1976 to 1980 period.

g. Fuel Cost Increases

On January 10, 1973, EPA promulgated regulations requiring that by July 1, 1974, gasoline marketers make 91 research octane number, lead-free gasoline generally available for use in vehicles equipped with lead-sensitive control systems. At the same time, for the purpose of public health, EPA proposed regulations requiring that the lead content of leaded gasoline be reduced to an average of 1.25 grams per gallon (gpg) by January 1, 1978. On November 28, 1973, EPA promulgated revised lead regulations providing for a phased reduction in the average lead content of all grades of gasoline produced by any refinery over a 4-year period. Refineries were to be restricted to 1.7 gpg beginning January 1, 1975, with annual reductions to bring the level to 0.5 gpg by January 1, 1979.

A court decision set aside the 0.5 gpg by 1979 regulation making it difficult to determine what the lead standards will be. For this report, the lead phase-down is assumed to take place as directed in the revised regulations.

The cost per gallon of fuel due to the lead regulations is expected to increase by 1.09 cents for 1975 and 1976, 1.3 cents for 1977 through 1979, and 1.5 cents for 1980.

The total costs for light-duty vehicles due to emissions controls and lead regulations are summarized in Table IV.4.

TABLE IV-4 ESTIMATED NATIONAL COSTS - ATTRIBUTABLE TO EMISSION CONTROLS FOR LIGHT-DUTY VEHICLES[1], 1973-1980. (BILLIONS OF DOLLARS)[4]

CALENDAR YEAR	EQUIPMENT	MAINTENANCE FOR LIGHT-DUTY VEHICLES	INCREASED FUEL CONSUMPTION[2]	FUEL PRICE INCREASE[3]	ANNUAL TOTAL
1973 (Incremental)	1.00	.94	1.36	-	3.30
1974 (Incremental)	.76	1.07	2.37	-	4.20
1975 (Incremental)	1.64	.99	2.29	.60	5.52
1976 (Incremental)	2.06	.86	1.93	.63	5.48
1977 (Incremental)	2.46	.71	1.38	.77	5.32
1978 5/ (Incremental)	4.89	.69	1.29	.93	7.80

1. Vehicles under 6000 pounds gross vehicle weight.
2. Fuel prices assumed (cents.gal): 1973, 41.6; 1974-75, 55; 1976, 61; 1977, 63; 1978, 65, 1979. 67; 1980,69; this penalty will obviously increase further due to the increase in gasoline prices. Current prices are already in excess of assumed figures.
3. Increases due to lead regulations (cents/gal): 1975-76, 1.09; 1977-79, 1.3; 1980, 1.5.
4. Current dollars used 1973-74; December 1974, dollars used 1975-80.
5. Assumes full statutory standards.

SOURCE - Cost of Clean Air Act 1975 - Report of the Administrator, 1975, unpublished draft.

2. Heavy-Duty Vehicles

a. Emission Standards

Separate emission-control regulations have been in effect since 1970 for new heavy-duty gasoline and diesel truck engines manufactured for use in over-the-highway trucks and buses of over 6000 lb. gross vehicle weight. Trucks under 6000 lb. gross vehicle weight are considered light-duty vehicles and have been dealt with in the previous section of this report.

b. Gasoline Engine Controls

Through 1973, the emission control technology used for heavy-duty gasoline engines was similar to that employed for light-duty vehicles through the 1972 model year. For this reason, and because EPA has made no detailed equipment cost estimates of heavy-duty gasoline truck engine controls, this report assumes that the per-vehicle cost increment for control equipment on 1970-1973 engines is equal to that for 1972 passenger-car engines, minus the cost of fuel evaporation controls. The equipment cost is estimated to be $24 per vehicle. For model years 1974-1980, it is assumed that equipment costs will be equivalent to 1973 passenger cars control costs, minus the cost of EGR and evaporative controls. For 1974 and beyond, therefore, the equipment costs are assumed to be $50 per vehicle.

Annual incremental maintenance costs for heavy-duty gasoline engine controls for 1968-1980 are assumed to be equivalent to the passenger car cost for 1968-1974, or $16 per vehicle.

Fuel consumption penalties are estimated to be 3 percent for 1970-73 period and 5 percent for 1974 and beyond. The baseline fuel economy is assumed to be 8.5 miles per gallon.

Total cumulative estimated annual costs for heavy-duty gasoline truck emission controls for the period 1970-1980 are $4.59 billion.

c. Heavy-Duty Diesel Engine Controls

Emission standards for smoke, HC, CO, and NOx, including those for 1974, have been attained largely through modifications to the fuel injection system. NOx and smoke are the most difficult emissions to control. (Even uncontrolled diesels are usually well within CO standards). Equipment cost penalties are considered nominal. Further, it is estimated that no fuel consumption penalties have been incurred. Accordingly, at this time, no national cost penalty is attributed to diesel-truck engine emission controls.

B. BENEFITS OF MEETING EMISSION STANDARDS

1. Air Quality Improvement

The pollutants of concern in this report are CO, HC and NOx generated by mobile sources and their relationship to ambient exposures to CO, Oxidant (of which HC is a precursor), and NO_2 (of which NOx is a precursor).

Trends will be discussed for specific areas because there are insufficient historical data to examine national trends. The analyses of specific areas are based on data from the National Aerometric Data Bank (NADB) as well as trend summaries from several State and local reports. While different criteria were used for the NADB, State, and local analyses, data cover a 3 year period at a minimum.

The available information presents a somewhat mixed picture. Progress is being made in achieving the NAAQS for oxidant and CO in the Los Angeles Air Basin, the San Diego Air Basin, the San Francisco Air Basin, and in Sacramento. In Philadelphia, total oxidants declined from 1965 through 1972 with a somewhat unexplained increased trend from 1972 into 1974. While there is no clear trend in CO in Philadelphia, progress is being made in achieving the 8-hour CO NAAQS in New Jersey, New York, and Washington States.

HC levels are decreasing in the Los Angeles Air Basin and are unchanged in San Diego and Philadelphia. In contrast NOx levels are increasing in the Los Angeles Air Basin and Philadelphia and are relatively unchanged in San Diego.

a. California

Oxidant, nitrogen dioxide, and hydrocarbon. California oxidant data from NADB are examined for coastal Los Angeles, noncoastal Los Angeles, and the San Francisco Bay Area. In general, oxidant trends for the three groupings confirm the longer-term downward trends perviously reported. This improvement can be seen in both the magnitude of peak hourly concentrations of oxidant (Figure IV-1), as well as the number of values above the 1-hour National Ambient Air Quality Standards (NAAQS) (Table IV-5).

FIGURE IV-1. Composite averages of second highest annual 1-hour oxidant values for Los Angeles and San Francisco, 1970-1973

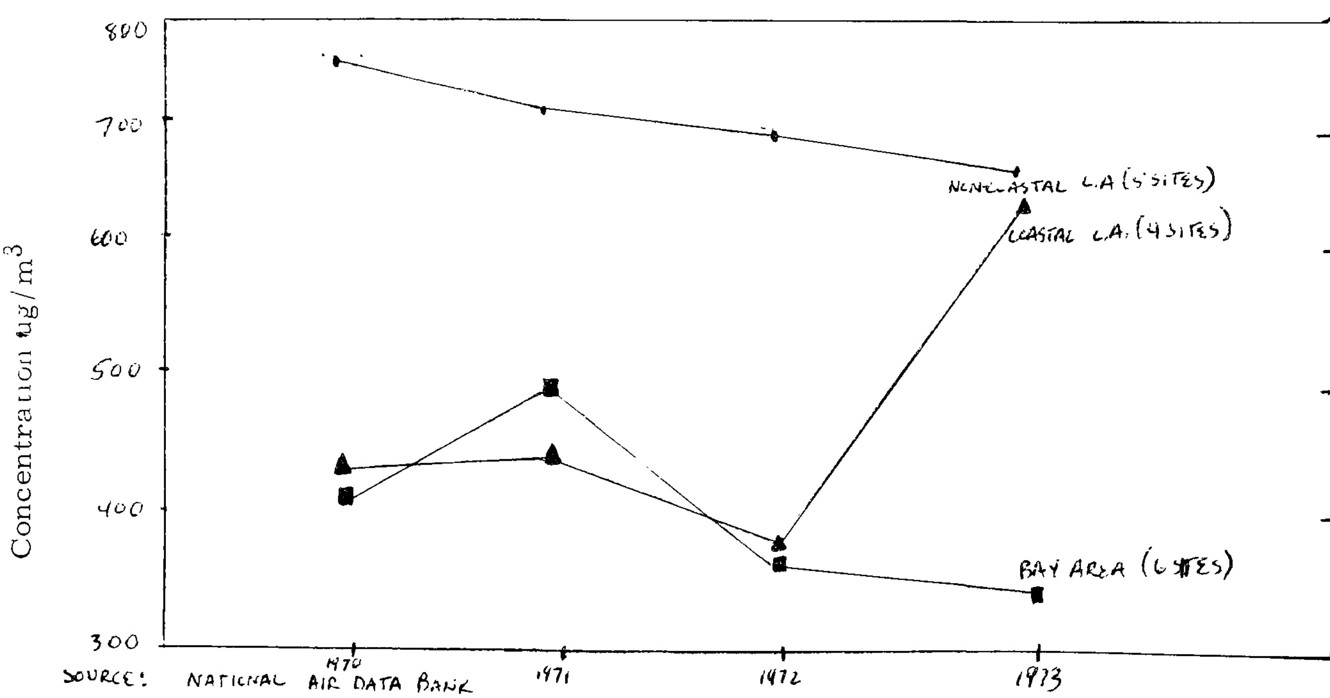


TABLE IV-5. OXIDANT POLLUTION IN LOS ANGELES AND SAN FRANCISCO, 1970-1973

Area	Number of Sites	Average annual number of values above 1-hour NAAQS oxidant standard 1/			
		1970	1971	1972	1973
Coastal Los Angeles	4	309	202	188	299
Noncoastal Los Angeles	5	886	768	698	703
San Francisco Bay Area	6	110	77	80	49

1/ 160 mg/m3.

Source: National Air Data Bank.

A notable deviation from the general pattern of decline in concentrations did occur, however, at four coastal sites in Los Angeles. The California Air Resources Board, in its report, "California Air Quality Data, January through March 1973" states that under the influence of extensive warm air and high pressure aloft, two oxidant smog episodes developed in the south coast air basin in June 1973. In addition, the frequency of there adverse conditions was unusual--high pressure aloft occurred on 20 days in June as opposed to a long-term mean occurrence of 8 days. (This emphasizes the potential impact of adverse meteorological conditions.) These conditions contributed to the slight increase in number of annual violations of the 1-hour NAAQS that occurred within the Los Angeles Basin during 1973.

The sites selected from the San Francisco Bay area have improved in both the second highest annual maximum and in the number of observations exceeding the NAAQS. The Bay Area Air Pollution Control District states, however, that the downward trend in oxidant concentration has leveled off somewhat since 1971.

Overall the general pattern seems to be one of the modest improvements in peak oxidant levels and in the frequency with which the NAAQS are exceeded. The improvements are consistent with legally scheduled reductions of HC.

The maximum 1-hour nitrogen dioxide ($N0_2$) levels have generally remained unchanged with some random fluctuations. The fluctuations are due to exhaust control systems for HC and CO emissions from 1966-70 model automobiles. These controls increased NOx emissions and thus increased ambient NO_2 concentrations. Control of N0x emissions in California began with the 1971 model year.

The average of maximum 1-hour HC concentrations generally remained constant from 1965 to 1973. Since the number of automobiles increased, this constant average may be attributed to control of HC emissions from automobiles. Control of crankcase emissions began in California in 1963, and exhaust control began with the 1966 model year.

Carbon monoxide. According to data from the NADB, the percentage of values in Los Angeles above the 8-hour CO standard declined from 14 percent in 1970 to 6 percent in 1973 (Table IV-6). During the same period, the San Francisco Bay Area sites showed less than 0.5 percent violations of the 8-hour CO standard. With respect to the annual second highest 1-hour average CO concentrations, both groups of sites made progress. In particular, Los Angeles sites, which have historically produced some of the highest 1-hour CO concentrations, have steadily declined from a composite level of 32 milligrams per cubic meter (mg/m) in 1970 to 26 mg/m in 1973.

TABLE IV-6. CARBON MONOXIDE POLLUTION IN LOS ANGELES AND SAN FRANCISCO, 1970-1973

		Average second highest annual 1-hour CO concentration, mg/m3				Average percentage above 8-hour NAAQS CO standard 1/			
Area	Number of sites	1970	1971	1972	1973	1970	1971	1972	1973
Los Angeles	10	32	32	31	26	14	11	8	6
San Francisco Bay Area	7	15	16	16	14	2/	2/	2/	2/

1/ Ten milligrams per cubic meter (mg/m^3).
2/ Less than 0.5 percent.

Source: National Air Data Bank.

b. Philadelphia

Total oxidants. Total oxidants show a downward trend in Philadelphia from 1968 through 1972, followed by an increase from 1972 through 1974 (Figure IV-2). The downward trend may be accounted for by the emissions controls systems on new cars and Philadelphia's Air Management Regulation V for controlling stationary sources of organic emissions, which reduced the amount of reactive hydrocarbons emitted into the air. The significant rise in oxidants since 1972 may be the result of the increased automotive NOx emissions which could be counteracting the HC reductions. 5/ Another explanation could be adverse meteorology. An EPA study 6/ reported high ozone levels in rural areas of Ohio and Pennsylvania due to adverse meteorology in 1973.

Nitrogen dioxide. Nitrogen dioxide levels increased in Philadelphia from 1972 through 1974 (Figure IV-2), possibly reflecting a temporary increase in emissions associated with the 1970-73 model cars. 5/ Future cars should emit less NO_2 (one component of NOx) and so ambient NO_2 concentrations should be lower.

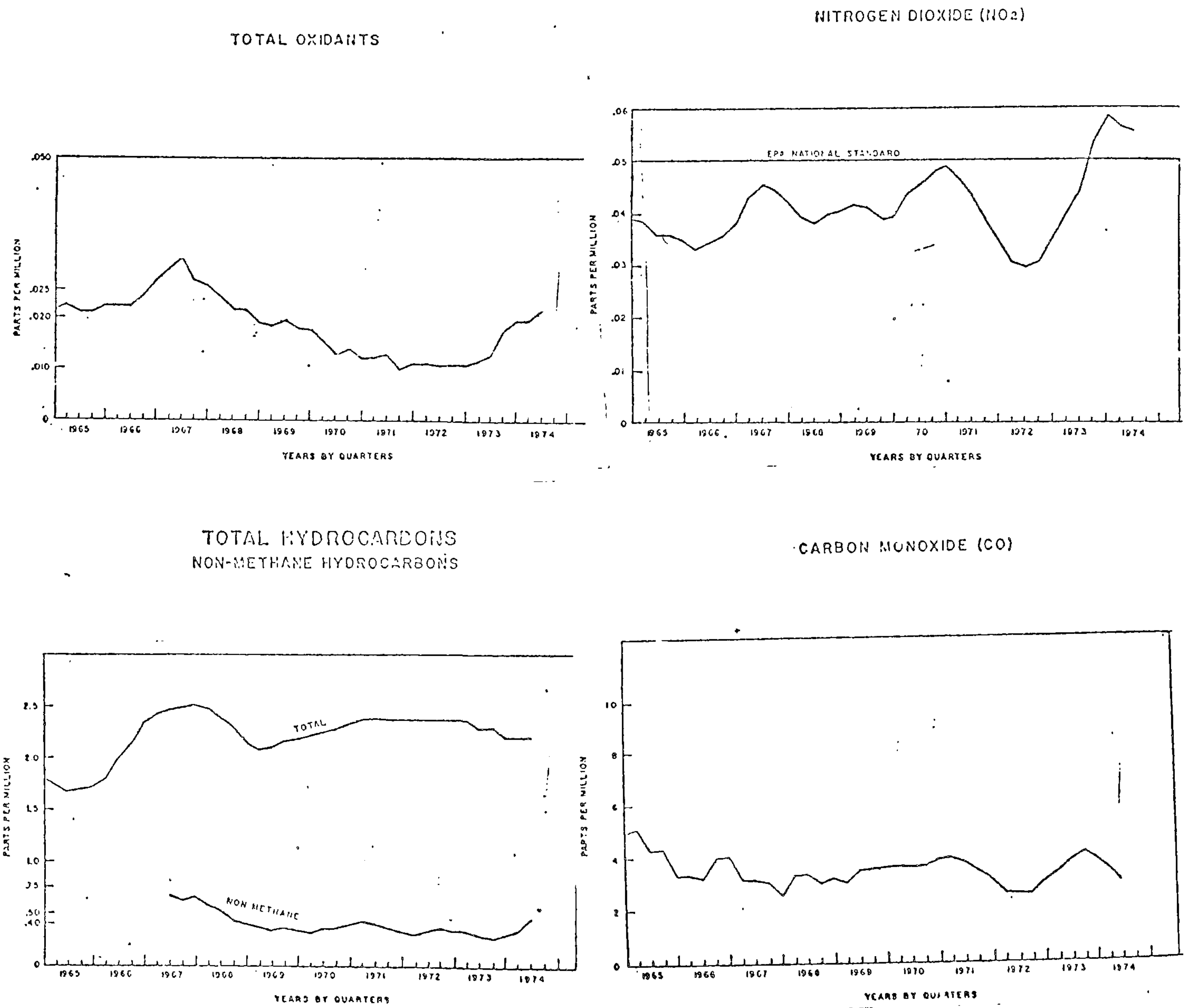
Total hydrocarbons. Total hydrocarbons in Philadelphia show no significant upward or downward trend (Figure IV-2). 5/ This is expected since approximately 80 percent of the hydrocarbons are methane which is thought not to represent an air pollution problem, and which also comes from decay of natural organic materials. The nonmethane hydrocarbons, on the other hand, are of concern because of their role in the formation of photochemical oxidants. With the exception of the past 12 months, these hydrocarbons are exhibiting a slight downward trend. The upward trend since then is difficult to explain since total HC emissions have been reduced by emission controls on new cars and vigorous enforcement of Philadelphia Regulation V.

Carbon monoxide. Carbon monoxide in Philadelphia does not show a clear trend (Figure IV-2), in spite of controls on automobiles and emission reductions achieved at stationary sources. 5/ The downward trend over recent months is attributed primarily to reduced use of automobiles during the 1973-74 fuel shortage. This trend may also be beginning to reflect emission controls on new cars.

c. New Jersey, New York, and Washington State

Carbon monoxide emissions declined in New Jersey, New York, and Washington, according to NADB (Table IV-7). The downward trend in the percentage of annual values above the 8-hour standard is noteworthy because this is the CO standard that is most frequently violated. The decreasing trend can be explained, in part, by the success of the Federal Motor Vehicle Emissions Control Program. In contrast, there appears to be no progress in reducing the annual second highest 1-hour average CO concentrations for each of the States. The apparent discrepancy between the two measures is not surprising. Short-term statistics such as the 1-hour maximum are notoriously influenced by irregular conditions, such as high CO levels due to extraordinary traffice tie-up. Consequently, the 1-hour maximum may be an unreliable indicator of real change. However, because of its relationship to the NAAQS, the 1-hour measure should not be totally ignored. Yet the percentage of values above a particular threshold, such as the 8-hour NAAQS, takes into consideration an entire year of data, averaging out a variety of conditions and is, therefore, a more stable indicator.

Figure IV-2. Total Oxidants, Nitrogen Dioxide, Total Hydrocarbons and Carbon Monoxide Concentrations, Philadelphia (29th and Race Streets)



Source: "Emissions Inventory and Air Quality Report to the Air Pollution Control Board." Air Management Service, Philadelphia Department of Public Health, Philadelphia, Pa., October 1974 (Revised).

TABLE IV-7. CO POLLUTION IN SELECTED STATES, 1970-73

Area	Number of sites	Average second highest annual 1-hour CO concentration, mg/m3 1970	1971	1972	1973	Average percentage above 8-hour NAAQS CO standard 1/ 1970	1971	1972	1973
New Jersey	15	20	30	28	30	16	9	10	7
New York	8		20	16	18		1	1	1
Washington	7		21	20	23		5	4	3

1/ Standard is 10 milligrams per cubic meter (mg/m^3).

Source: National Air Data Bank.

2. Health Effects of Pollutants Generated by Mobile Sources.

National emissions standards for mobile sources were established in the late 1960's primarily to protect public health. Standards for CO, HC and NO emissions were established by statute at levels aimed toward achievement of the NAAQS established by EPA in 1971. In accordance with 1970 Clean Air Act Amendments, the air quality standards were established at levels intended to assure protection of the health of certain susceptible segments of our population, with an adequate margin of safety. This assumes that susceptible persons should not experience aggravation of their preexisting diseases due to environmental pollution. If ambient exposures are below such effects levels, it is assumed that the otherwise healthy population will be unaffected. In reality, however, air quality standards must also be based on a consideration of the nature, increased frequency, and severity of reversible health disorders, as well as the increased risk of future and more irreversible diseases in otherwise healthy persons. Table IV-8 summarizes the adverse health effects which appear to be related to mobile source pollutants.

a. Methodology of Assessing Benefits

Assessment of public health benefits associated with automotive pollutant control is a complex process involving the following steps:

- Calculate changes in automotive pollutant emission factors.
- Project the impact of emission factors on ambient levels or calculate ambient pollutant trends.

TABLE IV-8. ADVERSE HEALTH EFFECTS DUE TO EXPOSURE TO NOx, CO, and OXIDANTS

Pollutant	Population-at-risk	Expected health effect
N0x	Those with pre-existing disease	Aggravation of asthma Aggravation of heart and lung disorders Increased severity of acute respiratory disease
	Otherwise healthy	Increased susceptibility to acute respiratory disease Diminished tolerance to exercise Increased risk of chronic respiratory disease Diminished lung function Carcinogenesis/mutagenesis (potential hazard due to nitrate or nitrite exposure)
CO	Pre-existing disease	Increased mortality among persons suffering myocardial infarctions Aggravation of heart disease
	Otherwise healthy	Increased risk of heart disease Decreased mental activity Tolerance to exercise diminished
Oxidant	Pre-existing disease	Aggravation of asthma Aggravation of chronic lung disease Aggravation of heart disease Decreased physical performance
	Otherwise healthy	Irritation of eyes and respiratory tract, headache Altered athletic performance Increased susceptibility to acute respiratory disease Increased risk of chronic lung disease Potential risk of mutagenesis/carcinogenicity Impaired fetal development Decreased visual acuity

- Estimate what fraction of ambient pollution is attributable to mobile sources.
- Derive dose-response functions for adverse effects related to automotive pollutants.
- Estimate populations at risk.
- Assess benefits by combining the data generated (synthesis).

This methodology will not necessarily furnish a quantitative assessment due to the lack of sufficient data. The following discussion is, therefore, a description of existing health benefits rather than a quantitative statement of those benefits.

Changes in Emissions and Air Quality Factors

Changes in automotive emission factors for CO, HC, NOx can be readily calculated. (See Section IV-6-1). Unfortunately, such changes cannot be simply or quantitatively related to ambient air quality trend data. This is due to a number of factors, not the least of which is the location where a pollutant is sampled and the difficulty in relating localized pollutant sources to the area-wide pollutant burden. The general air pollutant trends for automotive related pollutants were presented in the previous section on Air Quality Improvement.

Assessment of Mobile Source Contribution

Normally the fraction of ambient exposures due to automotive pollutants is estimated by calculating the pollutant contribution from all sources within an Air Quality Control Region based upon emission factors and number of sources. While this approach gives a general picture of the contribution of source emissions to the area-wide pollutant burden, it does not provide information related to site-specific exposures to pollutants from various sources, for example, CO exposure from mobile sources on a crowded freeway. Such exposures are also linked to human activity patterns in the urban-suburban area.

It is possible that greater public health benefits are being achieved from mobile source control of CO, which causes direct adverse health effects, than is evident from air quality data. Recent studies by Stewart et al, regarding reduced blood carboxyhemoglobin levels in Chicago blood donors from 1970-1975 lend support to this possibility. 8/

In attempting to assess the difficult question of mobile source contribution, the NAS estimated that approximately 1 percent of the total urban health hazard was from air pollutants. The ranges of estimates discussed was from 0.1 to 10 percent. The report further attributed the health hazard associated with automotive-generated pollutants at from 10 to 25 percent of the present air pollution related risk.

Dose Response Functions

Estimating dose-response for specific pollutant exposures is an extremely difficult task. While this has been attempted10/ such functions must be viewed as preliminary at this time due to a number of difficulties:

- Does-response functions assume no adverse health effects below the NAAQS--that is the NAAQS is assumed to be a "no-effect" exposure level.
- Not enough is known about the magnitude and frequency of exposure to environmental pollutants, thus making the translation of environmental monitoring into human exposure models a very complex undertaking.
- Health effects studies are very limited.
- There is usually no research base linking clinical, occupational epidemiological, and toxicological studies.

Population-at-Risk

In estimating the population-at-risk, it is necessary to examine both the relationship of populations to ambient pollution and the segment of those populations of concern from a public health viewpoint. The general population distribution can be determined from the 1970 Census (Table IV-9).

TABLE IV-9. U. S. POPULATION DISTRIBUTION BASED ON 1970 CENSUS

Location	Population 1/
Total	203,211,926
Rural	53,886,996
Urban	149,324,930
Urban in metropolitan areas over 2,000,000 in population	52,182,000

1/ County and City Data Bank Book, U. S. Department of Commerce, 1972.

Assuming that the air pollution problem related to the automobile is principally focused in urban centers exceeding 2 million in population, then 52 million people are susceptible to adverse health effects from such pollutants. 10/ The number of these people who experience aggravation of existing diseases can be approximated using baseline estimates for adverse health effcts (Table IV-10).

Reasonable predictions of premature death of increased mortality from mobile source-generated pollutants are possible only for CO. One estimate2/ suggests that the population-at-risk from increased mortality due to CO exposure in cities larger than 100,000 in population is 70,000. One can assume that about 75 percent of the CO exposure in such cities is related to mobile sources.

TABLE IV-10. ESTIMATED POPULATION-AT-RISK FROM CO AND OXIDANT AIR POLLUTANTS, WITH PRE-EXISTING DISEASES IN METROPOLITAN AREAS OVER 2 MILLION IN POPULATION 1/

Adverse Health Effect	Population Segment Experiencing Effects	Estimated Population-at-Risk
Chronic Heart and Lung Disease	27% of those over at 65	1,231,000
Asthma	3% of general population	1,560,000
Excess acute lower respiratory disease	6% of all children through age 13	731,000
Chronic bronchitis symptoms	2% in nonsmokers, 10% for smokers	2,335,000
	TOTAL	5,757,000

1/ From County and City Data Book, U. S. Department of Commerce, 1972.

These 5.7 million already susceptible persons constitute approximately 2.5 percent of the U. S. population and are located in regions where automotive-related pollutants contribute a greater percentage of the total pollutant burden than in rural or less urbanized areas.

EPA is currently working to develop better estimates of population exposure to support its health effects research and air pollution control programs. These estimates will be based on actual ambient concentrations as opposed to the crude population density basis used above.

Synthesis

Though the methodology presented above for assessing public health benefits is valid, it is not possible, with existing health effects data, to state quantitatively the public health benefits derived from control of mobile source emissions. The inability to make such an assessment should not be interpreted to mean that no benefits are resulting from emission control. Table IV-8, above, summarizes the available information which suggests that mobile source generated pollutants are related to definite adverse health effects in both the susceptible and otherwise health segments of the population. It is logical to assume that by reducing the ambient levels of pollutants causing adverse health effects the risk of the adverse effects themselves is decreased. Therefore, while a quantitative assessment cannot be made, it is possible to provide a qualitative assessment based on the air quality data presented earlier. When ongoing health effects research is completed, it is hoped that a more quantitative specific assessment will be available.

b. Qualitative Assessment of Health Benefits

The analysis of oxidant, HC, NO , and CO trends have been discussed in the previous section. "Air Quality Improvement." As noted therein, the data base is insufficient to examine national and regional trends, thus a few major cities are examined. Carbon monoxide, which is principally derived from mobile sources, appears to be decreasing, although no clear trend is obvious in some areas (Philadelphia). One would expect decreased localized exposures to automotive-generated CO also, due to the significant reduction in CO emissions from our current vehicle fleet. Thus, as suggested by Stewart, the population may be experiencing definite health benefits from decreased CO exposures.

Oxidant, appears to be decreasing in Los Angeles, San Diego, San Francisco, and Sacramento, but has increased since 1972 in Philadelphia. These changes are too small, however, to permit a statement of whether specific health benefits have or have not been achieved. If the generally decreasing trend noted in California continues it can be assumed that the risk of oxidant related diseases will decrease.

Nitrogen dioxide trends suggest that levels are increasing in some areas. One can conclude, that, to a limited degree, public health risks are increasing. Assessment of such risks is, however, extremely difficult because the NAAQS is an annual standard. A short term NOx standard, based upon health criteria, would permit a better assessment of public health related to both area-wide and localized exposure to NOx. The standard cannot be established, however, until further research is completed on health effects.

It is also likely that health benefits are resulting from decreased emissions of polynuclear aromatic hydrocarbons and certain other nonregulated organic pollutants. The control of these pollutants has indirectly resulted from control of HC and CO emissions.

In summary, mobile source control of CO is believed to be providing a net public health benefit. Assessing the public health benefits of HC and NOx control is more difficult because of the complex atmospheric interactions which cause HC and NOx to form oxidant. Such an assessment is also difficult because of the absence of a short-term health basis for assessing NOx effects. In general, oxidant appears to be decreasing while NOx is increasing. While the available data does not permit a quantitative assessment of derived health benefits, it does suggest strongly that where ambient levels of pollutants have been decreased, public health benefits in terms of reduced risk to pollutant related diseases have occurred.

FOOTNOTES

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6. "Investigation of Rural Oxidant Levels as Related to Urban Hydrocarbon Control Strategies." U. S. Environmental Protection Agency, Research Triangle Park, N. C. Publication No. EPA-450/3-75-036. March 1975.

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